Global Journal of Computer Science and Technology: E
Network, Web & Security
Volume 15 Issue 8 Version 1.0 Year 2015
Type: Double Blind Peer Reviewed International Research Journal
Publisher: Global Journals Inc. (USA)
Online ISSN: 0975-4172 & Print ISSN: 0975-4350

Spectrum Assignment Scheme based on Genetic Algorithm for Cognitive Radio Receiver

By Veena Gawde, B. K. Mishra & Rajesh Bansode
University of Mumbai, India

Abstract- Spectrum scarcity is one of the major challenges that the present world is facing. The efficient use of existing licensed spectrum is becoming most critical as growing demand of the radio spectrum. Different researches show that the use of licensed are not utilized inefficiently. It has been also shown that primary user does not use more than 60% of the licensed frequency band most of the time. There is need to find the techniques that can efficiently utilize the under-utilized licensed spectrum. One of the approaches is the use of “Cognitive Radio”. This allows the radio to learn from its environment, changing certain parameters. Based on this knowledge the radio can dynamically exploit the spectrum holes in the licensed band of the spectrum. This paper focuses on the performance of spectrum allocation technique, based on popular meta-heuristics Genetics Algorithm. Analyzing the performance of this technique using Matlab achieves mean fitness of 9.41. It provides fittest channels to the cognitive user on the basis of four priority parameters (genes) viz frequency, power, BER and modulation.

Keywords: cognitive radio, genetic algorithm, spectrum assignment, decision making, optimization.

GJCST-E Classification : I.3.7 I.4.1

SPECTRUMASSIGNMENTSCHEMEBASEDONGENETICALGORITHMFORCONITIVERADIORECEIVER

Strictly as per the compliance and regulations of:

Spectrum Assignment Scheme based on Genetic Algorithm for Cognitive Radio Receiver

Veena Gawde [α], B. K. Mishra [σ] & Rajesh Bansode [ρ]

Abstract- Spectrum scarcity is one of the major challenges that the present world is facing. The efficient use of existing licensed spectrum is becoming most critical as growing demand of the radio spectrum. Different researches show that the use of licensed are not utilized inefficiently. It has been also shown that primary user does not use more than 60% of the licensed frequency band most of the time. There is need to find the techniques that can efficiently utilize the under-utilized licensed spectrum. One of the approaches is the use of "Cognitive Radio". This allows the radio to learn from its environment, changing certain parameters. Based on this knowledge the radio can dynamically exploit the spectrum holes in the licensed band of the spectrum. This paper focuses on the performance of spectrum allocation technique, based on popular meta-heuristics Genetics Algorithm. Analyzing the performance of this technique using Matlab achieves mean fitness of 9.41. It provides fittest channels to the cognitive user on the basis of four priority parameters (genes) viz frequency, power, BER and modulation.

Keywords: cognitive radio, genetic algorithm, spectrum assignment, decision making, optimization.

I. Introduction

The radio spectrum is a natural resource, and used by transmitters and receivers in a communication network. In the past years, end user became service oriented which increased demand of wireless applications resulting in increased demand of bandwidth caused spectrum scarcity. The efficient use of licensed spectrum becomes a subject of recent contributions [1]. One of the leading technologies to answer the spectrum overcrowding problem is Cognitive Radio.

Simon Haykin defines Cognitive Radio, it as follows [2]: "Cognitive radio is an intelligent wireless communication system that is aware of its surrounding environment (i.e., outside world), and uses the methodology of understanding-by-building to learn from the environment and adapt its internal states to statistical variations in the incoming RF stimuli by making corresponding changes in certain operating parameters (e.g., transmit power, carrier-frequency, and modulation strategy) in real-time, with two primary objectives in mind:

- highly reliable communications whenever and wherever needed;
- efficient utilization of the radio spectrum.

The regulatory bodies focus on the operation of transmitter like FCC defines the cognitive radio as: A radio that can change its transmitter parameters based on interaction with the environment in which it operates [1]. So among all definitions it is observed that following terminologies are common "Observation", "Adaptability" and "Intelligence".

One of the most important components of the cognitive radio concept is the ability to measure, sense, learn, and be aware of the parameters related to the radio channel characteristics, availability of spectrum and power, radio's operating environment, user requirements and applications, available networks (infrastructures) and nodes, local policies and other operating restrictions. In cognitive radio terminology, primary users are defined as the users who have higher priority or legacy rights on the usage of a specific part of the spectrum. On the other hand, secondary users, which have lower priority, exploit this spectrum in such a way that they do not cause interference to primary users. Therefore, secondary users need to have cognitive radio capabilities, such as sensing the spectrum reliably to check whether it is being used by a primary user and to change the radio parameters to exploit the unused part of the spectrum.

Cognitive Radio receiver follows cognitive cycle which consists of two major parts shown in fig. 1, that are spectrum sensing and assignment [3]. Spectrum sensing is closely connected to *spectrum analysis*, which determines the characteristics of the spectrum bands that are detected through sensing. After detecting and analyzing the spectrum holes, the *spectrum decision* (or *spectrum assignment*) function selects the best available band according to some criteria [4].

The paper is structured as follows: In section II, a detailed description of challenges, issues faced an different approaches for CR spectrum assignment are given. proposed strategy that is GA for Spectrum assignment is also described. In section III, a CR decision-making process results are analyzed by matlab simulation. Finally, a conclusion is discussed.

Author α: Masters in Electronics and Telecommunication subject. Area of interest is Wireless Communication.
e-mail: veenagawde@gmail.com
Author σ: completed research work in MIMO OFDM in wireless communication. e-mail: tcet.principal@thakureducation.org

II. Spectrum Assignment

Spectrum assignment (SA) is a key mechanism that limits the interference between CR devices and licensed users, enabling a more efficient usage of the wireless spectrum. Spectrum assignment is a basic function of CRNs because it affects the normal operation of the network and is closely related to spectrum sensing, which provides information on the available spectrum. SA is responsible for assigning the most appropriate frequency bands at the interfaces of a cognitive radio device according to some criteria shown in Fig.1 that are maximize throughput, fairness, spectral effciency but at the same time, avoiding interference to primary users operating in the same geographical area.

Spectrum holes that are discovered by spectrum sensing are used as input to spectrum assignment, in order to find the optimum spectrum fragment that the SU should use according to its requirements [4], [5].

Cognitive spectrum assignment has some challenges that differentiate it from the conventional CA as shown in Fig. 2 in wireless networks. In traditional primary wireless networks, the spectrum is split among channels that have fixed central frequency and fixed bandwidth. Thus, traditional CA is the process of assigning a channel (namely the central frequency for use) to each user. In CRNs there is no standard definition for "channels". SUs can dynamically change the central frequency and the bandwidth for each transmission. As a result, the SA function for each SU should determine not only the central frequency, but also the spectrum bandwidth to be used by that SU (according its requirements), unless there is central node that selects frequencies/bandwidths for all SUs (in centralized SA). Moreover, the available frequencies and spectrum holes dynamically change with time and location. These additional challenges increase the complexity of the SA problem in CR networks [6].

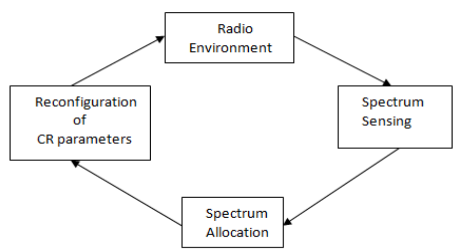

Fig.1 : Cognitive Radio Cycle

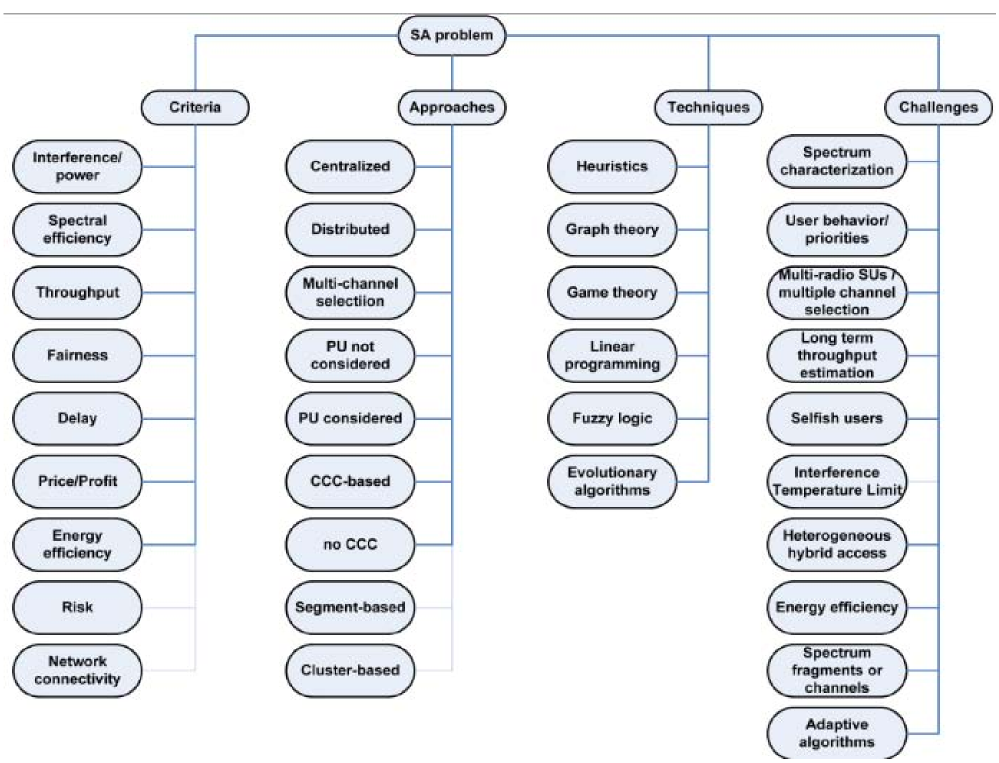

Fig.2 : Spectrum Assignment Problems

a) Introduction to Genetic Algorithm

Evolutionary algorithms are stochastic search methods that mimic natural evolution and the social behavior of species, a category of which are the Genetic Algorithms (GAs). Genetic algorithms are random search techniques used for finding optimal solutions to problems such as cognitive SA [4]. They are based on the principles of evolution and genetics and they are different from other optimization techniques because they are based on nature's notion of "survival of the fittest". This means that the "fitter" individual has higher probability to survive. To solve optimization problems, GA uses fitness functions and requires the parameters to be coded as chromosomes or finite-length strings over a finite alphabet, which are collected in groups called "populations". The populations are then divided into sets of feasible and infeasible solutions with the first being the channel assignments that satisfy the interference constraints or, in general, the requirements of the spectrum assignment [7], [8].

The procedure used in cognitive spectrum assignment based on genetic algorithms requires the definition of several parts, namely "population", "fitness function", "selection", "crossover", and "mutation". Chromosomes usually specify a possible confiict free channel assignment matrix, which is encoded in such a way to avoid redundancy of the elements. To evaluate the fitness of the chromosome, it should be mapped to the channel assignment matrix. For the initial population, the value of every bit in the chromosome is randomly generated and at each iteration, a new population is generated after applying selection, crossover and mutation functions. The evaluation of each chromosome is the objective of the optimizations, and several objective functions are used, such as maximizing throughput, fairness, etc [9].

The advantage of using GAs to solve the optimization problem of spectrum assignment in CR is that they can handle arbitrary kinds of constraints and objectives. Inefficient solutions are simply discarded by the algorithm. One major disadvantage associated with GA is that the process for finding the optimal solution is quite slow and there is always the risk of finding a local minima and not the globally optimal solution [7], [8].

b) Spectrum Assignment using genetic Algorithm

The computation of the GA starts from the assortment of the chromosomes which are randomly generated. Configurable radio parameters viz. transmit power, modulation, coding rate, symbol rate, packet size etc. represent genes of chromosomes. Size of population is taken according to number of cognitive users. Three genetic core operators which help for fittest solution are selection, crossover and mutation.

- *Crossover children* are created by combining the vectors of a pair of parents.
- *Mutation children* are created by introducing random changes, or mutations, to a single parent.
- *Stopping Criteria* depends on the number of maximum iterations and defined fitness value achieved [9].

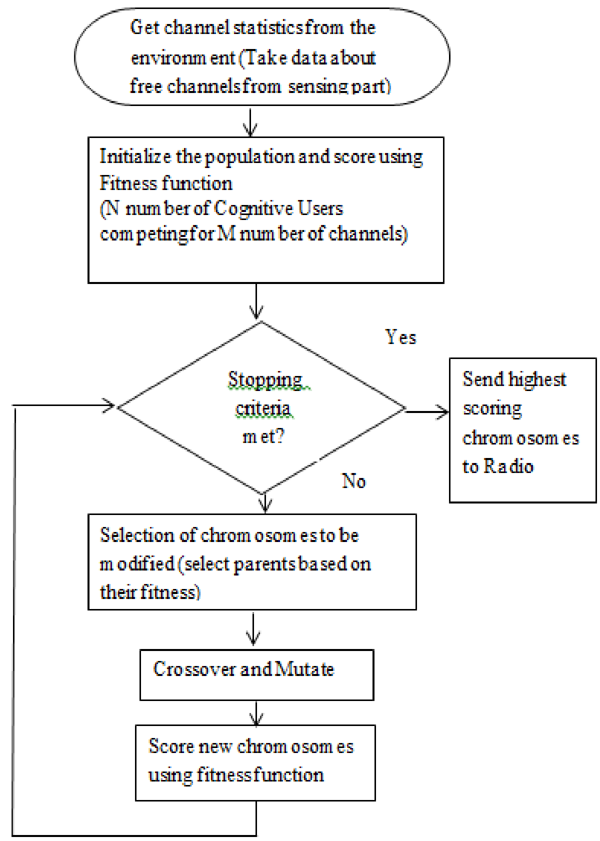

Fig.3 : Genetic Algorithm

Each primary user means a chromosome is identified by its parameters called as Genes. Four Genes are considered for implementation of this Genetic algorithm that are Frequency, Power, BER and Modulation [10].

Table.1 : Representation of chromosome structure

Order	1	2	3	4
Gene	Frequency	Power	BER	Modulation
Ranges	1-100	1-50	1-8	1-4
Bits required	7	6	4	2

Fitness is given by the following formula,

$$fi = \left[\frac{wi.\left|xi - x_i^d\right|}{x_i^d}\right] \; if \; \left|xi - x_i^d < x_i^d\right| \quad \ldots (1.1)$$

$$fi = Wi \qquad otherwise$$

The overall fitness value of chromosome F can be calculated as cumulative sum of indivisual fitness value of all the genes that is

$$F = \sum_{i=1}^{4} fi \qquad \ldots\ldots \; (1.2)$$

In [10] Fitness value in percentage can be given as,

$$Total\ fitness\ (\%) = 100\left[1 - \sum_{i=1}^{4} fi\right] \qquad \ldots (1.3)$$

III. Simulation Results and Discussion

Simulation parameters used are as follows:

Population	20
Generations	100
Crossover	80%
Best Fitness	9.0896

Fitness function shown above in equation (1.1) is optimized using GA tool.

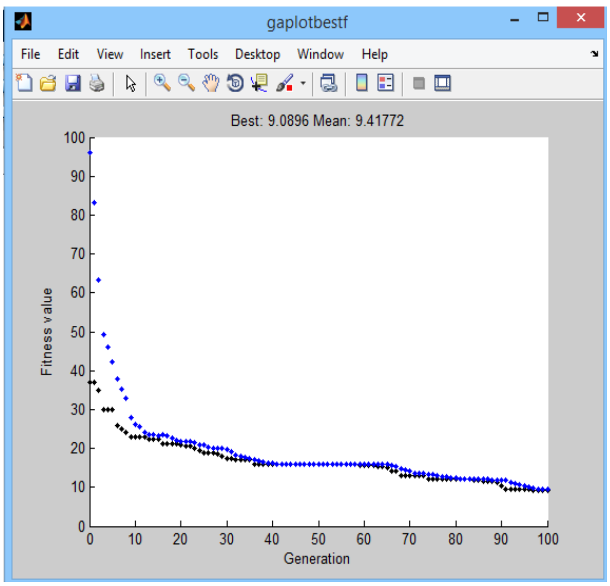

Fig. 4 : Fitness value for number of generations

The graph shown in fig 4 shows mean and best fitness value for number of generations GA is set. Here, for 100 number of generations fitness value is evaluated. As number of generations increases, mean and best value of fitness comes closer. Best value and mean value of fitness achieved by this GA is 9.0896 and 9.41772. Higher value of fitness shows more number of candidate channels are available to get occupied by cognitive users.

From parent population, child population is generated. Initially population of 20 is taken and then by crossover of 0.8 and mutation operation child population is generated. As shown in Fig. 5, Each parent population is operated by optimization tool and randomly few are mostly selected to create their child population further. Thus Crossover and mutation operators increases the population and enhances the performance of GA

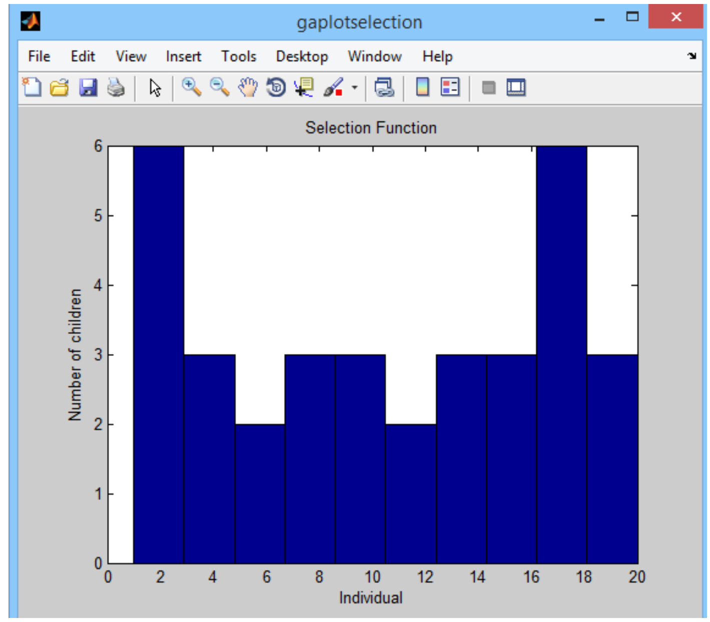

Fig. 5 : Fitness value for number of Children population generated Versus Indivisual

In this plot shown in Fig.6, Frequency is having high priority to decide selection of channel to avoid interference, power is having second priority and then BER and modulation are almost with equal priorities. As mentioned in table 1, Frequency, power, BER and

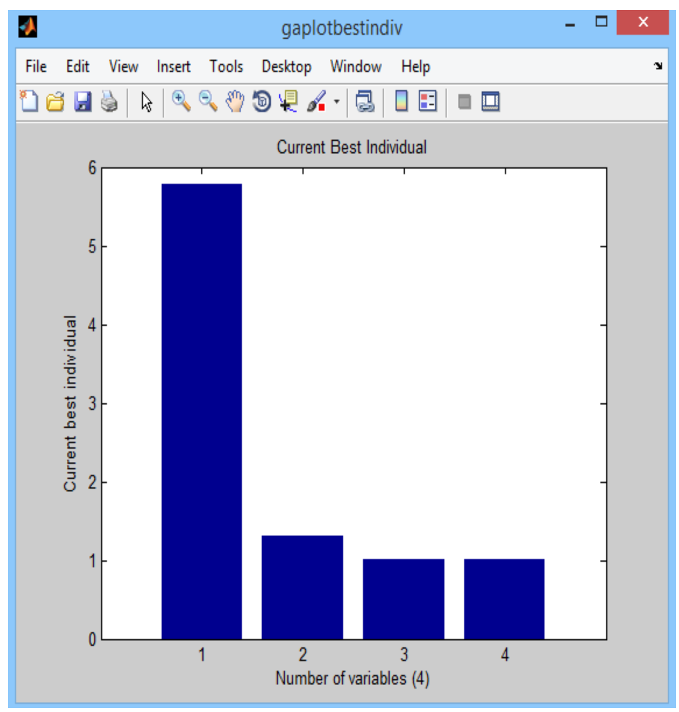

Fig. 6 : Current Best indivisual versus Number of variables

Modulation are the parameters on the basis of which channel suitability for assignment is checked.

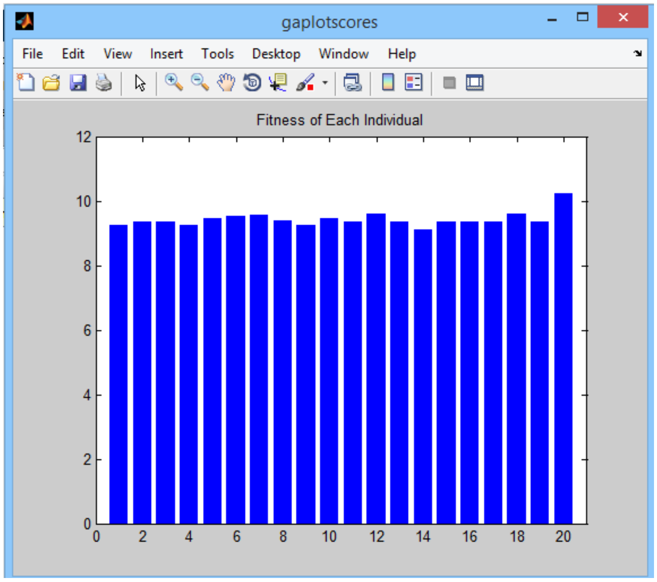

Fig. 7 : Fitness of each Indivisual

Fig. 7 shows fitness of each indivisual obtained in all iteartions of GA.

IV. Conclusion

This work shows that the fitness function of the individual parameters or genes increases with increase in number of generations, but this performance is always not linear. This performance of the G.A. is due to the existence of other genes in the chromosome structure that affect the decision-making process, to reach an optimal solution. This is for the reason that the optimal solution reached by the Genetic Algorithms may have to cooperation for an individual gene to have a better solution for another gene in the structure at the same moment and therefore obtain a better overall fitness value of the chromosomes. GA actually go for the nearby possible values for each gene along with the available pool of solutions. Also, the range for decision-making connected with each gene affects the decision-making process. A gene with a lesser range i.e. modulation gene in this case have a higher fitness value, while with a bigger range i.e. frequency gene in this case will have a worse fitness value in the optimal solution found by the GA, over the number of generations. This mean that the individual fitness values for the genes may not increase in the same manner, however the total fitness value stay almost 9.41 all through the generations and find the nearby probable best values in the existing pool of solutions .

References Références Referencias

1. J. Mitola III and G. Maguire Jr, "Cognitive radio: making software radios more personal," *Personal communication, IEEE,* vol .6, no.4, pp. 13-18, 1999.
2. S. Haykin, "Cognitive radio: brain-empowered wireless communications," *IEEE Journal on Selected Areas in communications,* vol.23, No. 2, pp.201–220, 2005.
3. Nolan, K., Doyle, L. ; S. Oh ; Cabric, D. "Cognitive radio: Ten years of experimentation and development," *IEEE Communication Magazine*, vol.49,no.3, pp.90-100, 2011.
4. B. Wang and K. Liu, "Advances in cognitive radio Networks: A Survey," *IEEE Journal of Selected Topics in Signal Processing*, Vol. 5, No. 1, Feb 2011.
5. E. Tragos, S. Zeadally, A. Fragkiadakis and V. Siris, "Spetrum assignment in Cognitive radio Networks: A comprehensive Survey," *IEEE Communications Surveys & Tutorials, 2013.*
6. L. Lu, X. Zhou, U. Onunkwo and G. Li, "Ten years research in spectrum sensing and sharing in cognitive radio," *EURASIP Journal on Wireless Communications and Networking,* 2012.
7. T. Rondeau, Bin Le, C. Rieser, "Cognitive radios with Genetic algoriths: Intelligent control of software defined radios," *Proceeding of the SDR 04 Technical Conference,* 2004.
8. Z. Zhao, Z. Peng, S.Zheng, J. Shang, " Cognitive Radio Spectrum allocation using Evolutionary algorithms," *IEEE Transactions on Wireless Communications, vol.* 8, NO. 9, 2009.
9. M. Kaur, M. Uddin and H. Verma, "Optimization of QOS parameters in cognitive radio using adaptive genetic algorithm," *International Journal of Next-Generation Networks (IJNGN), Vol.*4, No.2, June 2012.
10. S. Singh, G. Singh, V. Pathak, K. Roy, "Spectrum Management for cognitive Radio using Genetic Algorithm," *Neural and Evolutionary Computing (cs.NE), cornell University Library,*2011.

This page is intentionally left blank